Article

Mar 8, 2019

Remote Injection Systems

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Key Points

- Zoo veterinary technicians properly trained in remote injection may prepare, operate, and maintain a variety of drug delivery systems.
- All safety precautions must be employed when preparing and operating these devices.
- Choosing the appropriate piece of equipment for remote injection facilitates successful drug delivery while minimizing the risk of injury to the animal.

Because of the wide variety of species involved and the diversity of exhibit habitats, remote injection is essential in zoo veterinary medicine. Veterinary technicians working in a zoo environment must be able to recognize, prepare, and use many different types of remote administration equipment. This article describes the equipment used in remote injection procedures, how it is operated and maintained, the safety precautions that must be taken when using these systems, and the conditions under which each piece of equipment is used.

With proper training, veterinary technicians can become proficient in the techniques associated with remote injection systems. However, even the most skilled technician may be presented with challenges during a remote delivery procedure. Therefore, technicians who use remote injection equipment must be able to identify the potential causes of equipment failure. The two main types of remote injection equipment commonly used in zoos are blowpipes and dart guns. A third system, the pole syringe, is not always categorized as a remote delivery system but is a tool that requires a high degree of skill and understanding for its proper use.

The zoo technician who is adept in remote injection techniques is an essential part of the veterinary medical team (Haulena M: Personal communication, The Marine Mammal Center, Sausalito

,
CA
, 2005). Technicians trained in darting may be assigned duties such as administering vaccinations or treatments via remote injection. Good darting technique is also valuable in emergency situations, such as the escape of an animal. In such an event, veterinarians and technicians can be divided into dart teams, maximizing the chances of quickly and properly capturing the escapee (Levens G: Personal communication, Cincinnati Zoo and Botanical Garden,
Cincinnati
, 2005). The technician's ability to perform remote injection becomes even more critical when an emergency requiring this technique arises and no veterinarian is available (Purnell C: Personal communication, North Carolina Zoo,
Asheboro
,
NC
, 2005).

History

Remote injection equipment has been around for thousands of years. The earliest tools, used for hunting, included arrows, spears, and poisoned darts made of wood splinters. Modified bows and blowpipes constructed out of wood or cane were used to project these weapons.[1] These primitive instruments are the basis for modern techniques that allow zoo veterinary staff to immobilize, vaccinate, or administer drugs to intractable animals that are not trained to receive injections. Remote injection techniques using a projectile syringe also facilitate the safe capture of an escaped animal that cannot be netted or properly secured without immobilization (Levens G: Personal communication, Cincinnati Zoo and Botanical Garden, Cincinnati, 2005). These methods are also used for domestic species in free-range situations, urban wildlife, and stray companion animals.[2]

Tools for Remote Injection

Blowpipes

Two kinds of blowpipes are used for immobilizing, vaccinating, or medicating animals. Lung-powered pipes are used when a small volume of drug has to be delivered to an animal confined in a small area. Compressed atmospheric air- or gas-powered pipes are used to administer larger drug volumes and have a longer projectile range.

To use a lung-powered blowpipe, the technician rapidly exhales into one end of the instrument, propelling the dart through the other end. These pipes consist of one or two aluminum tubes up to 2 m long.[3] A mouthpiece on the tube allows the operator to make a tight seal with the lips so the dart can be expelled with adequate force. Lung-powered blowpipes are the simplest remote drug delivery system and offer several advantages over other delivery systems.[4] These instruments propel lightweight darts at a low velocity, minimizing trauma to the animal on impact; therefore, they are well suited for smaller animals.[5] The lung-powered pipe is often preferred over compressed air or CO_2

projection systems because it carries a lower risk of injury, even if the animal is hit in an area that is not part of a large muscle group (Crossett V: Personal communication, Louisville Zoological Garden, Louisville, KY, 2005). However, because of their light weight and low velocity, darts from these pipes may not effectively penetrate thick hides and may be affected by environmental factors such as wind. In addition, the projectile range of a lung-powered dart is limited to less than 20 m and the darts have a maximum volume capacity of 3 ml. Frequent target practice with the blowpipe is required before adequate range and accuracy can be attained.[3,5]

Non-lung-powered blowpipes

consist of a tube attached to a pistol grip. The dart is propelled from the pipe by compressed air or gas discharged from the pistol. Compressed air-powered projectors commonly use air supplied by a foot pump connected to the pistol by a hose. A manometer on the pistol or pump allows the operator to monitor pressure adjustment. Once the desired pressure is attained, the hose is disconnected from the pistol. Gas-powered blowpipes consist of a pistol grip attached to a unit containing a carbon dioxide (CO_2) cartridge and a manometer. CO_2 is pumped into the pistol reservoir by compression of a forefinger valve on the CO_2 unit,[6] and the manometer displays the amount of pressure within the pistol reservoir. The operator can adjust the pressure by compressing the trigger or the forefinger valve.

When adjusting the pressure in an air- or gas-powered blowpipe, the operator must consider how much drug is to be delivered as well as how far the dart will have to go to reach its target. Once the desired pressure is attained, the blowpipe is attached to the pistol. The longer the pipe, the greater the potential distance the dart will travel. When the trigger is pulled, the compressed air or gas within the pistol is released, expelling the dart. The trigger must be squeezed quickly, or the air or gas may not be released forcefully enough for the dart to hit its target.

Air- or gas-powered blowpipes can deliver larger volumes (up to 10 ml) at longer distances (1 to 30 m) compared with lung-powered devices.[3] In addition, these systems are almost silent, which is beneficial when darting highly reactive animals. A disadvantage of the CO_2-powered system is that it may be affected by environmental temperature. Warm temperatures may increase the CO_2 pressure, extending the flight distance of the dart syringe; cold temperatures may decrease the pressure, reducing the range of the dart syringe.[5] To avoid these pitfalls, it may be helpful to shoot a few darts at a practice target to determine the pressure needed for the live dart to hit its mark. The practice darts must weigh the same as the live dart and be propelled the same distance the live dart will have to travel.

See **Box** for Glossary.

Glossary

Anthelmintic – Medication that kills certain types of intestinal worms; dewormer

Autoclave – Machine that uses pressurized steam to sterilize materials

Blank – Cartridge loaded with propellant and a wad but no projectile (e.g., bullet)

Caliber – Diameter of a bullet or other projectile

Cold sterilization – Immersion of an item into a liquid chemical for a given time to create a disinfected or sterile condition

Dart – Syringe that is propelled from a projector and delivers a calculated drug dosage at a distance, automatically injecting its contents on impact

Exudate – Fluid containing protein and cellular debris that has escaped from a blood vessel and been deposited in tissue

Hoof stock – Hoofed, typically herbivorous, quadruped mammal

Manometer – Instrument for measuring the pressure of gases or vapors

Muzzle (of a blowpipe or gun) – The forward discharging end

Operant conditioning – Method of training an animal so it forms an association between a behavior and a consequence

Opioid – Synthetic narcotic that has opiate-like qualities but is not derived from opium

Remote injection projector – An instrument, such as a blowpipe, rifle, shotgun, or pistol, that is used to propel a dart and deliver a calculated drug dosage

Septicemia – Presence of disease-causing microorganisms in the blood

Dart Guns

Dart guns, available in rifle, shotgun, and pistol models, can safely and effectively deliver darts over a greater distance compared with blowpipe projectors.[5] These devices are also equipped with sights to help the operator aim the gun and properly place the dart. Many zoos carry all three types of dart guns, and decisions regarding which one to use are based on the animal or situation. For example, rifles are commonly used for animals in large, open areas of land, such as hoof stock exhibits (Crossett V: Personal communication,
Louisville
Zoological Garden
,
Louisville
,
KY
, 2005). Because pistols have shorter barrels, they are often used when animals must be darted at close range. Both rifles and pistols are particularly effective in penetrating the thick skin of pachyderms, such as the rhinoceros. Any type of dart gun — rifle, shotgun, or pistol — may be used during an animal escape emergency.

Dart guns used in the zoo setting have one of three propellants: gas generated from a .22-caliber blank cartridge (powder-charged), compressed CO_2, or compressed air supplied by a foot pump or air tank.[3] One type of powder-charged projector has a port that may be opened and closed to regulate the amount of expanded gas propelling the dart. This feature lets the operator adjust the dart range and velocity according to dart size and distance.[5] The other type does not have a velocity control, so the operator must use cartridges of different strengths to compensate for various distances. Powder-charged projectors may propel darts with volumes of up to 25 ml; however, larger volumes may reduce the potential for accurate long-range shots. These guns can safely and effectively deliver darts over distances up to 120 m.[3]

Dart guns that use CO_2 or compressed air have an effective projectile range shorter than that of powder-charged projectors. CO_2 projectors are capable of effectively delivering a dart up to 70 m, whereas compressed-air projectors have an effective range of up to 50 m.[3] These systems are usually equipped to deliver drug volumes up to 10 ml — possibly more, depending on the manufacturer. Advantages of these systems over powder-charged projectors include a lower risk of impact injury and fewer maintenance requirements. One drawback, however, is that, as with CO_2-powered blowpipes, heat and cold have a direct effect on the flight distance of darts projected by CO_2 projector systems.

Darts

Darts used to administer antibiotics, vaccines, anthelmintics, mineral and vitamin compounds, and immobilization drugs to animals consist of five basic parts: the needle, the syringe barrel, a separating plunger, the injection solution, and the tailpiece.[2] There are four major mechanisms for pushing the dart plunger forward to inject the drug solution. It is important to note that darts typically are not interchangeable between projection systems.

Plunger Mechanisms

The two simplest methods of advancing the plunger involve the expansion of a compressed substance. One type of dart uses butane gas or air that is introduced through the tail end of the dart and compressed behind the plunger; the other uses a tailpiece with a coiled spring that compresses behind the plunger when the tailpiece is screwed onto the dart. The needles that are placed on these darts have a rubber sleeve that slides over the needle port(s) before the dart is pressurized. After the drug chamber has been filled, the needle is attached and the dart is pressurized by the air, butane gas, or coil. The sleeve on the needle seals the drug solution within the dart until it is dislodged during penetration of the animal's skin. Exposure of the needle port(s) causes the gas pressure, air pressure, or compressed coil to be released, pushing the plunger forward.[7]

Another discharge mechanism is powered by the chemical reaction between a sodium bicarbonate solution and acetic acid. The impact of the dart making contact with the animal causes the acid and bicarbonate to mix, and the reaction produces enough gas to push the plunger forward. Other darts use a small explosive charge placed behind the plunger. A spring separates the charge from its firing pin until the dart reaches the target; the force of impact causes the firing pin to overcome the spring's tension and make contact with the charge. The charge detonates and produces gas that pushes the plunger forward.[7]

Comparison of Remote Injection Projectors

Projector	*Propellant*	*Distance (m)*	*Volume (ml)*	*Animal Type*
Blowpipe (lung powered)	Expulsion of breath	<20	3	Small and large; thin skinned
Blowpipe (powered)	Compressed CO_2 or air	30	10	Medium to large; thick skinned
Dart gun (pistol, rifle, shotgun)	Compressed CO_2, compressed air, or .22-caliber blank cartridge	120	25	Large; pachyderms

Because of their injection speed, darts that use an explosive charge mechanism are more likely than other dart types to cause tissue damage. Also, when using this type of dart, the operator must make sure the firing pin is inserted into the dart correctly. If the charge is not facing the right direction, the dart will discharge within the gun barrel.[7] Darts compressed with air have a slower injection time, which may allow the animal to remove the dart before all the contents has been injected.

Single-Use Darts

Single-use darts such as Pneu-Darts (Pneu-Dart,
Williamsport
,
PA
) use either an explosive charge or an acid-base reaction to expel the dart's contents. These darts combine the dart and needle in a one-piece unit. They are available in various sizes, and because the discharge mechanism is already inserted and ready to use, minimal preparation is required.[5] Also, because single-use darts are disposable, they do not require cleaning, thereby reducing the risk of accidental exposure to potent opioids (Hedberg G: Personal communication, San Francisco Zoo, San Francisco, 2005; Clark B: Personal communication, Roosevelt Park Zoo, Minot, ND, 2005) and keeping the possibility of malfunction to a minimum.[5] One disadvantage of single-use darts is cost. Disposable darts must be continually replaced; therefore, the institution's budget and frequency of remote injection should be considered when purchasing these darts.

Syringes and Tailpieces

Dart syringes are made of aluminum or plastic. Aluminum darts are more resistant to destruction by the animal being darted than are plastic darts. Tails, or stabilizers, may consist of strands of yarn or plastic fins molded from synthetic polymers.[3] The tailpiece balances and streamlines the dart as it travels through the air. It also forms a seal in the barrel of the projector so that the pressure released by the discharge mechanism has enough surface area to push against to project the dart. If the tail were absent, the released air or gas would leak around the dart.

Needles

Dart needles may be smooth or possess barbs or collars that serve to retain the dart in the animal. Darts with smooth needles will generally fall out quickly when the animal moves. Smooth needles may also bounce out of the animal if the dart is highly pressurized. Although barbs and collars prevent needles from falling or bouncing out, they may cause tissue damage on removal. However, some barbs and collars are biodegradable and dissolve on contact with tissue fluids. Needles expel their contents from the standard front opening (end port) or through a side port with the front occluded. Side ports are less likely to become plugged with tissue or skin as the needle enters the animal, but needles with end ports expel their contents more rapidly.[3]

▲ Lung-powered blowpipes with mouthpieces.

Pole Syringe

The pole syringe, also known as the jab stick or stick syringe, consists of a hypodermic syringe contained in or attached to the end of an extension pole.[5] In the basic pole syringe design, the extension pole is attached to and acts as the syringe plunger. Operation of this device requires strategic needle placement and careful manipulation of the pole. Because drug injection begins as soon as the needle meets resistance, the operator must employ a quick jab motion when inserting the needle. Adding a buffer of air within the syringe may help delay drug administration until the needle penetrates the muscle. Upon muscle penetration, steady pressure must be maintained against the animal until all the solution has been injected.[4] Pole syringes are used most often on animals confined in small cages or holding pens and provide a relatively atraumatic method for daily injections.[7] While most volumes of drug are administered easily with the basic pole syringe, volumes greater than 5 ml increase the time required to deliver the drug.[2] Newer designs include automatic pole syringes that allow larger volumes of drug to be delivered in 1 second or less.

Certain constraints are associated with the use of pole syringes. Long pole syringes may be difficult to control and may reduce accuracy. A jabbed animal may reach around and bite at the syringe, possibly ingesting it, or a quick movement by the animal may cause the needle to bend. Pole syringe needles have the potential to break off, but most devices have protective shields that enclose and support the hub. A dark-colored pole syringe is recommended because it is less likely than a lighter-colored pole to be visible to the animal.[4,7]

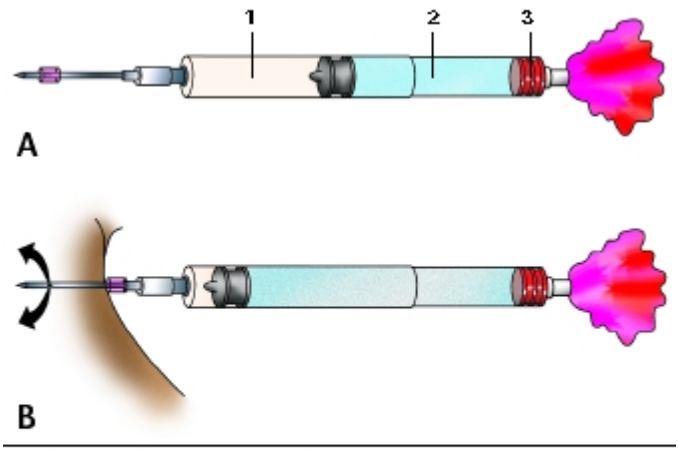
Animal Injuries

Because of the force of their impact, darts can seriously injure an animal or cause infection at the injection site. These health risks may be reduced, however, by taking some simple precautions and having a thorough understanding of the equipment being used.

▲ Blowpipe powered with attached CO_2 unit.

A dart injection site is an optimal environment for bacterial growth that will result in infection, abscess, tetanus, or septicemia if left untreated.[5] Injection-site abscesses occur most often in pigs, when debris on the surface of the animal is incorporated into the tissue with the dart (Haulena M: Personal communication, The Marine Mammal Center, Sausalito, CA, 2005). Local infection may result in any darted animal if the dart's needle or the liquid within the dart is not sterile. Darts traveling at high velocities increase the risk of tissue trauma. Misplaced shots may result in penetration of the needle shaft into bone, causing a fracture. Rapid injection of a drug by an explosive charge mechanism may cause tissue disruption, hemorrhage, and pain; if the dart needle is embedded in the marrow cavity of a long bone at the time of injection, bone-shattering hydraulic pressure may be created.[7] Primates and some carnivores may bite the dart syringe or reach around and grab it, causing the needle to break off.[4]

Selecting the proper charge, velocity, syringe/needle combination, and delivery site will reduce the risk of dart impact injuries. Ideally, the dart should strike on the downward trajectory to minimize tissue trauma.[2] Dart impact injuries can also be avoided by using power projectors only on animals weighing more than 15 kg (33 lb); darting animals only in the muscle masses of the shoulder, upper hind leg, or rump; and using a needle that is no longer than necessary.[5] If a long needle is all that is available, an additional sealing sleeve may be placed at the posterior end of the needle near the hub. In addition, understanding the capabilities and limitations of darting systems and becoming proficient in using the equipment through practice will improve accuracy and reduce impact trauma.[2]



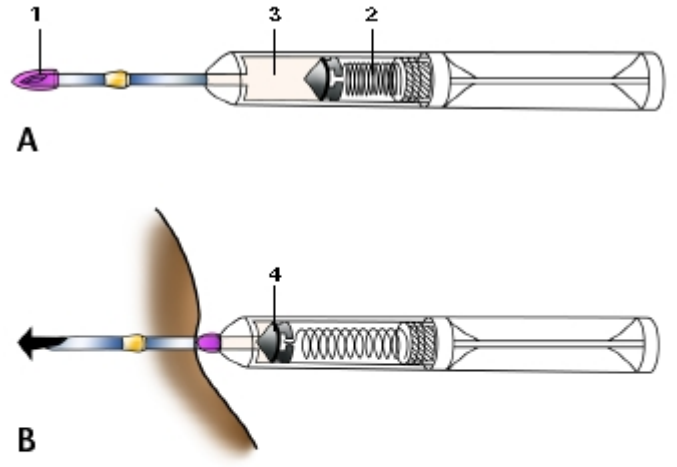
▲ Air-pressurized blow dart in flight (A) and following skin penetration (B). Note the different components: (1) drug chamber, (2) pressurization chamber, and (3) one-way valve.

Training animals through operant conditioning to receive injections by hand is a great way to avoid the pain and stress of darting for routine injections (Crossett V: Personal communication, Louisville Zoological Garden, Louisville, KY, 2005).

Preparing for Remote Delivery

Which remote delivery system to use depends on the size of the animal, the amount of drug to be administered, the distance between the animal and the projector, and personal experience.[7] Once the

appropriate delivery system and projectile dart have been chosen, the equipment must be systematically assembled and checked for functionality. Ideally, the zoo veterinary staff will have a routine method for preparing equipment and will anticipate and avoid equipment failure by checking and rechecking darts and needles (Hedberg G: Personal communication, San Francisco Zoo, San Francisco , 2005).



▲ Spring-pressurized dart. (A) The dart is ready for firing, with (1) a tight-fitting cap occluding the dart's needle while (2) the coiled spring pressurizes (3) the agent. (B) Dart in the final stage of injection. The needle's cap slides backward as the needle penetrates the skin, allowing the spring to push (4) the plunger forward, injecting the agent.

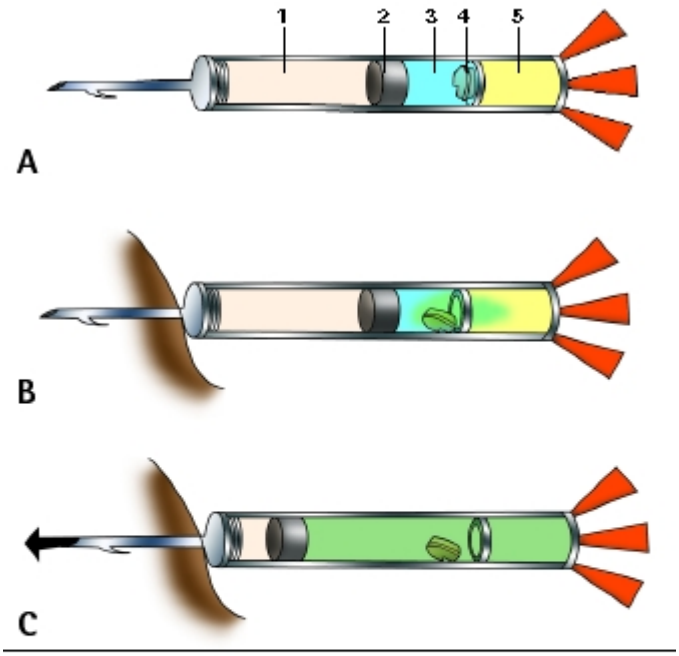
Adequate preparation for remote injection also includes training and practice. Programs such as Safe Capture International Incorporated (www.safecapture.com) offer workshops in which participants can become familiar with the latest delivery systems and techniques. Zoo internships also offer the opportunity for hands-on training under the guidance of an experienced darter. The American Association of Zoo Veterinarians often holds conferences at which manufacturers demonstrate their equipment. Firearm instruction and safety classes are another great resource for anyone who wants to learn how to use pistols, rifles, and shotguns safely. Those who rarely perform darting procedures may benefit from regular practice using paper targets, a deer decoy, or meat attached to a bale of hay (Port M: Personal communication, Tampa, FL, 2005).

Safety

General safety protocols must be observed when handling remote delivery equipment before, during, and after any darting procedure. In addition, special guidelines must be followed when a controlled drug such as carfentanil, etorphine, or diprenorphine is to be delivered.

Assembling Darts

When preparing remote delivery equipment for routine procedures such as vaccination or medication, several precautions must be taken in assembling darts. To avoid injury, pliers may be used when securing needles to dart syringes as well as during disassembly. The needle must be securely attached to the dart before pressurizing to prevent leakage or separation of the needle from the dart (Haulena M: Personal communication, The Marine Mammal Center, Sausalito , CA , 2005). Darts should be pressurized just before delivery, away from other people and animals. A 60-ml syringe case can be placed over the dart and directed away from people and animals during pressurization (Pond J: Personal communication, Lincoln Park Zoo, Chicago , IL , 2005). Dan-Inject (Fort Collins , CO) and Telinject (Agua Dulce , CA) darts come with a snug-fitting protective cover. Once the dart is pressurized, personnel in the surrounding area should be notified. A pressurized dart should be handled carefully when loaded into the projector. The muzzle of the blowpipe or gun must always be pointed in a safe direction, away from people and animals, until the actual darting takes place. A dart gun should always be treated as if it were loaded with real bullets. The safety should remain on or the gun should be uncocked until just before delivering the dart.[3] Used darts may be placed in a long container with a tight-fitting lid (Pond J: Personal communication, Lincoln Park Zoo, Chicago, IL, 2005). Because of the pressure remaining in the air chamber, reusable darts should be handled carefully when being cleaned.



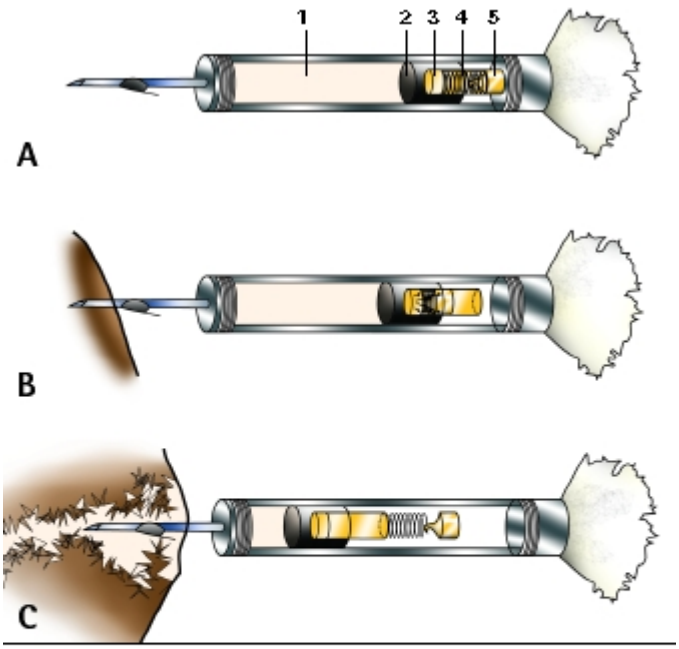
Dart syringe using a soda–acid injection system; both components are in liquid form, which helps to accelerate the reaction. Note the components: (1) Drug chamber; (2) plunger; (3) saturated solution of sodium bicarbonate; (4) asymmetric weight seated in an O-ring; (5) acetic acid. (A) Dart in flight. (B) Dart on impact. When the weight falls forward, the soda and acid are able to mix. (C) Dart during the last stage of injection.

Handling Drugs

Carfentanil and etorphine are synthetic opiates with a clinical potency 10,000 times that of morphine. They are typically used for immobilizing large hoof stock. Diprenorphine is a partial antagonist used to reverse the effects of etorphine and, when administered alone, has a narcotic effect similar to that of etorphine.[8] These three agents are extremely toxic to humans. Death is most often caused by respiratory failure. Human exposure may result from accidental injection with a syringe or dart; absorption through the mucous membranes of the mouth, eyes, or nose; or direct absorption through broken skin.[3]

Agents such as carfentanil, etorphine, and diprenorphine should be handled only by trained staff, such as veterinary technicians and veterinarians. Drugs to reverse the effects of these agents should be readily available in case of accidental exposure during dart preparation and pressurization. Anyone working with these substances must wear a protective face shield, a surgical face mask, gloves, long sleeves, and long pants. All other personnel working near these agents must also wear protective clothing and gloves. When a staff member is working with a toxic substance such as carfentanil, etorphine, or diprenorphine, a second person who is capable of performing cardiopulmonary resuscitation and first aid should be standing by.

As an extra precaution when handling a dart with a potent opioid, a recycled infant incubator may be used as a loading chamber. Using the arm portholes, the operator can load the dart within the incubator and place it in a container before removing it from the incubator (Clark B: Personal communication, Roosevelt Park Zoo,
Minot
,
ND
, 2005). The container should have a tight-fitting lid clearly labeled with the name of the agent loaded in the dart. The operator may pressurize the dart using a large syringe case and should alert other staff members of the charged dart.



▲ Dart with a powder charge injection system. Note the components: (1) Drug chamber; (2) plunger; (3) explosive charge; (4) spring; (5) firing pin. (A) Dart in flight. (B) Dart impacting skin with firing pin compressing the spring and detonating the charge. (C) Dart during the last stage of injection. Note the tissue damage that is possible with this type of dart system.

After the dart has been discharged, the veterinarian or veterinary technician should release any remaining pressure in the dart, remove the dart from the animal, and wipe off and clearly mark the injection site. Only a veterinarian or veterinary technician should handle a discharged dart. The used dart should be put back in its container and secured with a lid. Protective gear should be worn when cleaning the used dart to avoid exposure to any residual drug in the syringe or on the needle parts. For extra safety, the infant incubator may also be used as an unloading chamber, especially when the dart contains a large amount of unused drug.

Cleaning, Maintenance, and Storage

To ensure reliable and consistent functioning, drug delivery equipment must be cleaned and maintained on a regular basis according to the manufacturer's recommendations and instructions. Dart guns in need of minor repairs may be taken to a local gunsmith for service. For major equipment repairs, the distributor or manufacturer may have to be consulted.[5]

General Guidelines for Preparing Remote Delivery Equipment

- **Test each dart** to see if it holds pressure both immediately before filling the drug chamber and after cleaning.
- **Choose the appropriate-size needle** for the species being darted.
- **Check needle patency** by passing air through the bore with a regular syringe.
- **Straighten the needle shaft if slightly bent;** discard the needle if it cannot be straightened.
- **Confirm the sharpness** of the needle point.
- **Make sure the dart plunger slides back and forth** easily.
- **Lubricate the sealing sleeve** with a small amount of antibiotic ointment so it will slide along the needle upon impact.
- When using a CO_2 pistol, **make sure there is plenty of CO_2 left in the cartridge** by checking the pressure gauge.
- **Have extra remote injection materials and supplies** on hand.

Dart syringes should be disassembled and cleaned immediately after use to prolong the life of the dart (Hedberg G: Personal communication, San Francisco Zoo,
San Francisco
, 2005). The drug chamber of plastic darts that use gas- or air-pressure discharge mechanisms should be flushed with a mild cleaning detergent such as Alconox (
White Plains
,
NY
). The drug chamber may then be rinsed with sterile water; however, it is important to note that the air chamber should remain dry. Silicone may be applied to the inside of the drug chamber, and the plunger slid back and forth to ensure easy movement. If the syringe is cracked or the plunger does not move smoothly, the dart should be discarded. Plastic darts may be sterilized with ethylene oxide after they have completely air-dried. Aluminum darts should be completely disassembled and cleaned. Cleaning kits with dart syringe brushes are available to help remove gross debris. Aluminum parts may be autoclaved or cold sterilized; after these parts have been cleaned and dried, the inside of the dart, O-ring seals, and plunger should be lightly coated with silicone lubricant.[5] Dart syringes and parts should be stored at room temperature and are commonly kept in the pharmacy under normal temperature and humidity conditions.[9]

Needles should be flushed with water immediately after use. If cleaning is delayed, some drugs may settle out of solution and crystallize within the needle. Needles may be immersed in an ultrasonic cleaner to help break up hardened debris within the needle bore. Needles that are permanently occluded and unable to be straightened and sharpened should be discarded. Needle patency must be reestablished and confirmed before the needle is sterilized.

Tailpieces made of fabric should be clean and soft and not stiff from contamination with moisture or exudates. Special combs are available to straighten tailpieces before darting. The strands of fabric should be even and symmetric and may be trimmed for aerodynamic stability. Tailpieces may be stored in test tubes to maintain their shape.[4]

Ways to Prevent Dart Impact Injuries

- **Select the proper delivery equipment**, including projector, dart, and needle.
- **Select the proper power charge** to discharge the dart's contents.
- **Select the proper velocity** at which to deliver the dart.
- Limit the use of power projectors to **animals weighing >15 kg (33 lb).**
- Dart animals only in the **muscle masses of the shoulder, upper hind leg, or rump.**
- **Do not use needles that are longer than necessary;** if a long needle must be used, place an extra sealing sleeve near the hub of the needle.
- **Understand the capabilities and limitations** of the system being implemented.

Blowpipes should be cleaned on a regular basis using a weighted tool with a piece of cotton attached to the end. After the tool is passed through the pipe several times, the pipe is lightly coated with a lubricant. Dart guns such as rifles, shotguns, and pistols require visual inspection and cleaning after each use. These projectors should not be disassembled beyond the manufacturer's recommendations. The operator must always ensure that the safety is on before he or she cleans the gun. Gun oil is commonly used to clean the exterior parts of the gun as well as the barrel; cleaning kits with brushes are also available for cleaning gun parts and barrels. While dart guns are generally stored unloaded in a dry, dust-free environment, some CO_2 dart guns should be stored charged and in the cocked position.[5] Before proceeding with cleaning, maintenance, or storage operations, the operator should always consult the equipment manufacturer's instructions.[5]

Purchasing Remote Injection Equipment

When purchasing remote injection equipment, several factors must be considered, including the size and species of animal(s) to be darted, the type and volume of drug to be administered, and the distance over which the drug will be delivered (Pond J: Personal communication, Lincoln Park Zoo, Chicago, IL, 2005). The experience of the staff members who will be using the equipment must also be considered. It is essential that dependable and reliable remote injection equipment be available to the

veterinary staff and other trained personnel at all times, so cost should not be a major criterion when purchasing these systems.[5] Good-quality equipment will perform reliably for many years as long as it is handled properly and receives preventive maintenance on a regular basis.

General Handling Policies When Using Potent Opioid Agents

- **Before the darting procedure, notify local emergency center or emergency medical teams** of when and where the procedure will take place.
- **Have a human emergency kit, oxygen tank, and treatment protocol** available.
- **Always work in pairs.**
- **Make sure all staff members handling opioid agents are wearing protective equipment**, including long sleeves, long pants, a splash mask, a surgical face mask, and gloves.
- **Ensure that all other personnel working with the darted animal are wearing protective equipment**, such as gloves, long sleeves, and long pants.
- **Brief all staff involved in the darting procedure** on safety precautions and how the procedure is to be carried out.
- **Prepare the animal's reversal agent dose** before drawing the immobilizing drug.
- **Label all syringes** clearly.
- **Transport syringes in a tightly closed container** labeled with the agent(s) being used.
- **Cover the dart with a large syringe case when pressurizing it,** and point it in a safe direction.
- **Depressurize the dart before removing it from the animal.** Mark the dart site, and rinse it with water to remove drug residue.

Sometimes the zoo veterinary technician is given the task of researching the types of remote injection equipment that may best suit the zoo's needs. The zoo technician may also be responsible for restocking remote injection supplies and updating the equipment operated at the facility. The technician may set up an appointment with a darting equipment sales representative to assess the zoo's needs. The representative can inform the technician about new and improved equipment and offer guidance in selecting the tools that would be most beneficial for the zoo (Hedberg G: Personal communication, San Francisco Zoo, San Francisco, 2005). In addition, most manufacturers have Web sites that offer online catalogs of their systems and supplies; these sites are a good starting point for the zoo technician researching remote delivery systems.

Conclusion

Qualities to Look for When Purchasing Remote Injection Equipment[6]

- Safe and simple to assemble and operate
- Easy to clean, maintain, and service
- Durable and easy to transport
- Reliable, with consistently accurate performance
- Appropriately versatile for use on different species under varying environmental conditions
- Not noticeably affected by temperature, humidity, or altitude changes
- Accompanied by a valid manufacturer's warranty on parts and repair for at least 1 year

The most important aspect of selecting, using, and maintaining a remote injection delivery system is the safety of personnel. A safety policy must be in place and strictly adhered to for every type of remote delivery system, regardless of the procedure. Following a standard protocol for preparing remote injection equipment helps ensure the smooth and successful delivery of a dart. Proper care and routine maintenance will keep remote delivery equipment in good and predictable working order.

Remote injection has become an integral part of veterinary medicine within the zoo setting and has enhanced the standard of care for exotic and wild animals housed in captivity. Technicians who are trained to perform remote injection techniques can lighten the workload of veterinarians and allow them to focus on other projects throughout the zoo. A skilled technician who is familiar and comfortable with operating darting equipment will prove to be a valuable asset in any zoologic facility.

Acknowledgment

Special thanks to Virginia Crossett, RVT, Hospital Supervisor,
Louisville
Zoological Garden
, for posting the Remote Injection Survey on the International Zoo Veterinary Technicians Forum on the Association of Zoo Veterinary Technicians Web site (azvt.org)

Additional Reading/Information

English T: Plan for projectile dart restraint. *Aust Vet J* 78(10):654, 2000.

Fowler M, Miller E: *Zoo and Wild Animal Medicine: Current Therapy 4*.
Philadelphia
, WB Saunders, 1999.

Kleiman DG, Allen ME, Thompson KV, Lumpkin S: *Wild Mammals in Captivity: Principles and Techniques*. Chicago,
University
of

Chicago
Press, 1997.

Klos H, Lang E: *Handbook of Zoo Medicine: Diseases and Treatment of Wild Animals in Zoos, Game
Parks
, Circuses, and Private Collections*. New York, Van Nostrand Reinhold Company, 1982.

Palmer Cap-Chur Equipment: *Operating Instructions*. Accessed September 2006 at palmercapchur.com/index.cfm?paraID=49.

Pneu-Dart: Accessed September 2006 at pneudart.com.

Safe-Capture International Workshops. Visit safecapture.com to register.

REFERENCE:

1. Wenker C: Anesthesia of exotic animals. *The Internet Journal of Anesthesiology*. Accessed September 2006 at ispub.com/ostia/index.php?xmlFilePath=journals/ija/vol2n3/zoo.xml.

2. Smith A: Remote injection systems for exotic animals. *Proc TNAVC* 9:716-718, 1995.

3. Kreeger T: *Handbook of Wildlife Chemical Immobilization*, international ed. Fort Collins, CO, Wildlife Pharmaceuticals, 2002, pp 32-38, 56-70.

4. Fowler ME: *Restraint and Handling of Wild and Domestic Animals*, ed 2. Ames, Iowa State University Press, 1995, pp 36-44.

5. Nielsen L: *Chemical Immobilization of Wild and Exotic Animals*. Ames, Iowa State University Press, 1999, pp 31-70, 81-82, 211-212.

6. Telinject USA, Inc: *Remote Injection System*. Accessed September 2006 at telinject.com.

7. Jessup DA: Remote treatment and monitoring of wildlife, in Fowler ME (ed): *Zoo and Wild Animal Medicine: Current Therapy* 3. Philadelphia, WB Saunders, 1993, pp 499-504.

8. Handling Policy for Controlled Animal Drugs. Cincinnati, Cincinnati Zoo and Botanical Garden, 2005.

9. Product information: Operating Instructions for Telinject Syringes. Telinject USA, Agua Dulce, CA, 2005.